METHOD FOR SCORING AND DELIVERING TO A READER TEST ANSWER IMAGES FOR OPEN-ENDED QUESTIONS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of and incorporates by reference co-pending Application Ser. No. 10/113,035, filed April 1, 2002, now U.S. Pat. No. 6,684,052, which itself is a continuation of Application Ser. No. 09/707,252, filed November 6, 2000, now U.S. Pat. No. 6,366,760, issued April 2, 2002, which itself is a divisional application of Application Ser. No. 08/903,646, filed July 31, 1997, now U.S. Pat. No. 6,173,154, issued January 9, 2001, which are commonly owned with the present invention and which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to systems and methods for imaging test answer sheets and, more particularly, to automated systems and methods for processing and storing test answer sheet images that include answers to open-ended questions.

Description of Related Art

The automation of test scoring is a complex problem that has generated a great deal of interest, owing to a significant economic pressure to optimize efficiency and accuracy and to minimize human involvement. Optimal mark reading (OMR) systems are well known in the art, such as those for scanning forms having pencil marks within preprinted areas such as ovals. OMR systems generally sense data recorded within the

preprinted areas by detecting light absorbed in the near infrared, which is referred to as NIR scanning. This method permits the differentiation of the pencil marks from the preprinted information, which is provided in a pigment that does not absorb in the NIR. OMR systems thus permit a gathering of data that is easily converted into digital form, scored against an answer database, and saved without consuming excessive storage space.

An additional level of complexity is added, however, with the inclusion of open-ended or essay-type questions. These questions must typically be scored by a human reader, and thus either the physical test form or a visible image thereof must be available for at least the time required for scoring. A digitally stored visible image can be obtained by an image processing apparatus, for example.

A multiplicity of systems and methods for addressing the scoring of test answer sheets have been disclosed in the art. For example, Poor (U.S. Pat. No. 5,452,379), Keogh et al. (U.S. Pat. No. 5,134,669), Clark and Clark et al. (U.S. Pat. Nos. 5,321,611; 5,433,615; 5,437,554; 5,458,493; 5,466,159; and 5,558,521) disclose systems and methods for combining OMR and image processing wherein only a predefined area of a document (an "area of interest") is captured and stored.

Another aspect of the problem of processing test answer sheets having both multiple-choice and open-ended questions involves the scanning apparatus used to convert a written document into digital data. The use of combined OMR and image capture devices is disclosed by Poor '379, Keogh et al. '669, Clark et al. '554.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a system and method for processing and scoring test answer sheets having both multiple-choice and open-ended questions.

It is another object to provide such a system and method that retains a full image of a test form so that it is retrievable by a scorer.

It is an additional object to provide such a system and method that captures OMR and image data in a unitary device.

It is a further object to provide such a system and method that obviates the need for trigger or timing marks on a test form.

It is yet another object to provide such a system and method that distributes answers for scoring to a qualified reader.

It is yet an additional object to provide a flexible system architecture for imaging test answer sheets, storing the images, and distributing the images to a qualified reader for scoring.

It is yet a further object to provide such a system and method that includes a tool for performing a geometric measurement upon a displayed image of an answer sheet.

These and other objects are provided by the imaging and scoring system and method of the present invention. The system includes integrated hardware elements and software processes for capturing optical mark and full visual images of an answer page, for storing the images, for retrieving the images, for distributing the visual images to a reader for scoring, for assisting the reader in scoring, and for monitoring the reader's performance.

The scanning system comprises means for sequentially advancing each page of a plurality of answer pages along a predetermined path. Positioned along the path are mark imaging means (OMR, optical mark recognition; OCR, optical character recognition) for capturing a location of an optical mark on each answer page and visual imaging means for capturing a full visual image of each answer page. A forms database in a server is provided that contains data on the physical location and type (e.g., multiple-choice or open-ended) of each answer on each page. Software means resident in the server operate with the forms database to determine whether the captured image contains an answer to an open-ended question. If such an open-ended answer is supposed to be found on the page being imaged, the full visual image of the page is stored.

In a particular embodiment the scanner further comprises means for aligning the page image without the use of timing or tracking marks. The aligning means comprises means for detecting a page edge, which is sufficient for pages having only open-ended answers.

The present invention further includes a system and method for distributing one of a batch of answer images to a reader for scoring. The answer images typically comprise open-ended answers such as are obtained from the scanning system and method as described above. Preferably each batch of answer images are from a common test, although this is not intended as a limitation.

The method comprises the steps of fetching a batch of answers to a test question from a storage device and placing them in a temporary cache. These fetching and temporary storing steps are preferably under the control of a server. This server contains

a database associating each answer batch with a qualification required of a reader. Another database resident therein contains a list of qualifications possessed by each reader.

A reader who is in electronic communication with the cache indicates a readiness for scoring, and that reader's qualifications, which are resident in the server, permit the routing to the reader of one of an available batch of answers based upon predetermined criteria such as priority associated with a test to be scored. An answer image from an appropriate answer batch is electronically delivered to the reader's workstation for scoring. Once the scoring of that answer is complete, the server will distribute additional answer images to that reader until the batch is completely scored or the reader exits the system. Typically, a similarly qualified group of readers score answer images from the same batch.

The present invention additionally includes a system and method for displaying a test answer page to a reader for scoring. In this aspect, the page number for a particular test is used to access a forms layout database, which contains a location of the sector on which the open-ended question is expected to be found. The page image is then formatted to display that answer sector to the reader. Means are also provided for permitting access to the remainder of the page, such as by scrolling on a workstation screen, or to additional pages if the item answer covers multiple pages.

Formatting also comprises providing a scoring protocol for the answer and displaying commensurate indicia to the reader to assist in scoring. For example, a button bar can be displayed on a screen, an item of which can be selected for entering a score.

Another scoring facilitator available to the reader comprises a geometric measurement tool that can be superimposed on an answer and manipulated to provide an indication of how close to an "ideal" answer the student has come.

Scoring is also assisted by an electronic querying system and method, whereby a query is electronically transmitted to successively higher levels of supervisors until an answer can be obtained. The answer is then electronically relayed back through the same levels so that all intermediate personnel can benefit from the knowledge.

In order to monitor the scoring effectiveness of a reader, means are provided for transmitting a calibration answer for scoring. The reader is unaware that this is not another answer in the regular workflow queue. The score granted by the reader can be compared against a target score to judge that reader's effectiveness. In addition, scoring time can be tracked to obtain a measure of scoring speed. Similarly, the calibration answer can be given to a plurality of readers for obtaining effectiveness and speed statistics for a group of readers.

The features that characterize the invention, both as to organization and method of operation, together with further objects and advantages thereof, will be better understood from the following description used in conjunction with the accompanying drawing. It is to be expressly understood that the drawing is for the purpose of illustration and description and is not intended as a definition of the limits of the invention. These and other objects attained, and advantages offered, by the present invention will become more fully apparent as the description that now follows is read in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic of a hardware configuration of a preferred embodiment of the scoring system.

FIG. 2 is a schematic of the data processing functions and applications of the scoring system.

FIG. 3 is a schematic of a network architecture useful in the scoring system.

FIG. 4 is a flowchart of representative image processing and storing steps in the method of the present invention.

FIG. 5 is a flowchart of a representative process for distributing an answer to a reader for scoring in the method of this invention.

FIG. 6 is a flowchart of representative steps in the scoring process of the present invention following the distribution of an answer to a reader.

FIG. 7A illustrates an exemplary page of a literature test having one multiple-choice question and one open-ended question.

FIG. 7B illustrates a display of the image processed from the page of FIG. 8A as displayed to a reader for scoring.

FIG. 8A illustrates an exemplary page of a geometry test having one multiple-choice question and one question requiring the student to draw a diagram.

FIG. 8B illustrates a display of the image processed from the page of FIG. 8A as displayed to a reader for scoring.

FIG. 9 is a flowchart of representative steps in the reader calibration process of the present invention for tracking scoring efficiency and effectiveness.

FIG. 10 illustrates an exemplary header sheet for a batch of test booklets.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A description of the preferred embodiments of the present invention will now be presented with reference to FIGS. 1-10.

The Image Capturing and Storage System and Method

A schematic of a hardware configuration of a preferred embodiment of the present invention is illustrated in FIG. 1, which includes the imaging and image storing elements, and in FIG. 3, which includes the network architecture. Software application elements are included in the data processing flow diagram of FIG. 2. A flowchart of representative image processing and storing steps is given in FIG. 4, and two exemplary answer pages are illustrated in FIGS. 7A and 8A. The imaging and scoring system **10** hardware elements include a scanner **20** for imaging answer pages. A preferred embodiment of the scanner **20** comprises a modified Scan-Optics 9000 unit, rated for 120 pages/min.

Standardized tests are typically given in batches to students belonging to a particular group, for example, a plurality of sixth-grade students from different schools and different classrooms in a particular geographical region. Each student receives a coded booklet comprising a plurality of pages, and, following test administration, all the test booklets are delivered to a scoring center for processing. A header page **13** (FIG. 10) provides alphanumeric character and OMR-readable data for tracking the booklets. Header page **13** includes, for example, such information as teacher name **131** ("Mrs.

Smith"), grade level **133** ("6"), and school code **132** (134274), the latter two having an associated "bubble" filled in for each number. This configuration is exemplary and is not intended as a limitation. One or more of such batches may together form an "order," and a number is also assigned to track this (e.g., all Grade 6 classes in Greenwich, Connecticut). Another tracking means comprises "cart number," which indicates a physical location of the booklets. Each test booklet is entered, for example, via bar code, for later demographic correlation with scores, and is cut apart into individual, usually two-sided pages (FIG. 4, step **899**).

The test booklet pages are stacked sequentially into an entrance hopper **201** of a scanner **20**, and each page **12** is fed by methods well known in the art onto a belt **21** for advancing the page **12** along a predetermined path (FIG. 4, step **900**). The belt **21** has a substantially transparent portion for permitting the page **12** to be imaged on both sides simultaneously by two sets of cameras.

A first set of cameras includes an upper **22** and a lower **23** camera, each filtered for infrared wavelengths. This set **22,23** is for optical mark recognition (OMR), used to detect the location of pencil marks, for example, filled-in bubbles such as are common in multiple-choice answers, on both sides of the page **12** (step **903**). Alternatively, OCR marks are detected and processed (step **903**).

The OMR scan data are greyscale processed by means **42** known in the art for detection of corrections and erasures. The data are then routed to a long-term storage device (step **906**), such as magnetic tape **41**, for later scoring and further processing in a mainframe computer **40**.

A second set of cameras includes an upper **24** and a lower **25** camera, each substantially unfiltered. This set **24,25** is for capturing a full visual image of both sides of the page **12** (step **907**).

The page **12** continues along the path on the belt **21** and is collected in sequence with previously scanned pages in an exit hopper **202**.

The scanner **20** is under the control of a first server **26**, such as a Novell server, which performs a plurality of quality-control functions interspersed with the imaging functions. Software means **261** resident in the first server **26** determine that each page being scanned is in sequence (step **904**) from preprinted marks on the page indicating page number. If it is not, the operator must correct the sequence before being allowed to continue scanning (step **905**).

The first server **26** also has software means **262** for determining whether the page **12** is scannable (step **901**). Pages containing OMR data contain timing tracks **125** as are known in the art (see FIG. 7A) for orienting the page with respect to optical mark position. A page that has these missing is not scannable, and a substitute page marked "unscannable" in placed into the document indicating to the reader that a request for a hard copy must be made before this page can be scored (step **902**).

In addition, a screen **27** is in communication with the first server **26** that displays to the operator a preselected number of visual images (step **911**). For example, the operator may choose to view every *n*th page scanned. Should the quality be deemed insufficient (step **912**), the scanner **20** is stopped (step **913**), maintenance functions or repairs are

performed (step **914**), and the affected group of pages is rescanned (step **900**). This is a custom-designed function, a scanning activity monitor, that automatically searches the output files looking for the latest cart-stack combination and then displays the latest images from the cameras **24,25** for operator review.

The first server **26** further contains a forms database **265** of answer pages that comprises data on the physical location of each answer and a type of answer for each page in the answer booklet. The answer type may be, for example, an answer to an open-ended question or a multiple-choice question. FIG. 7A illustrates a sample page **12** from a literature test, wherein Question #1 **71** is multiple-choice and Question #2 **72** is open-ended, with an answer space **73** provided for writing an answer **74**. Likewise in FIG. 8A, a sample page **12'** from a geometry test, Question #1 **81** is multiple-choice and Question #2 **82** is open-ended, with an answer space **83** provided for drawing a diagram **84**. A correlation is performed between the page number and the forms database (step **908**) to determine whether the page **12,12'** contains an open-ended answer. If so (step **909**), the page image is prepared for storage (step **910**); if not, the page image is not saved.

The first server **26** also contains means for detecting an edge, preferably an uncut edge **120**, of the imaged page. Edge detection is utilized to align the visual image for answer pages containing only open-ended answers. This is beneficial for several reasons: (1) the answer booklets are more economical to produce, since tracks do not need to be printed and printing accuracy is less important; (2) there is less chance of tampering; and (3) the booklets have greater aesthetic appeal.

A page image that is to be saved is stored temporarily in a second server, comprising a fast storage server **28** (step **915**) that has a response time sufficiently fast to keep pace with the visual image scanning step **907**. Such a second server **28** may comprise, for example, a Novell 4.x, 32-Mb RAM processor with a 3-Gb disk capacity. Means are provided here for ensuring that the OMR and image data are in synchrony (step **916**). If they are not, data may have to be reconstructed or images rescanned (step **917**).

The data are transferred at predetermined intervals to a third server **30** having software means **302** resident therein for performing a high-performance image indexing (HPII) on the visual image (step **918**). This is for processing the data for optical storage and retrieval (OSAR). Third server **30** may comprise, for example, a UNIX 256-Mb RAM processor with a 10-Gb disk capacity having 3.2.1 FileNet and custom OSAR software resident thereon.

The answer images are finally transferred to a long-term storage (step **919**) unit **34** for later retrieval. Such a unit **34** may comprise, for example, one or more optical jukeboxes, each comprising one or more optical platters. Preferably two copies are written, each copy to a different platter, for data backup.

Next the transaction log data are transferred to a fourth server **32**. Fourth server **32** may comprise, for example, a UNIX 64-Mb RAM processor having Oracle and FileNet software resident thereon.

Th Distribution and Qu u Monitoring System and Method

Once a complete batch of answer pages have been imaged and stored, a "batch" comprising, for example, all test booklets from a particular grade level from a particular school, scoring can commence. FIGURE 5 is a flowchart of an exemplary distribution process of the present invention, wherein a first step **950** comprises determining an answer batch from a queue to be scored during a particular time period.

In a preferred embodiment, a determination is made prior to the start of a scoring session as to which batches of answers are desired to be scored during that session. This determination may be based, for example, on predetermined criteria including an assigned priority, project number, order number, and number and type of readers available, and is entered into a fifth server **36**, which provides a communication link between the fourth server **32**, the cache **38**, reader workstations **50**, and the mainframe **40**, as will be discussed in the following (FIG. 1). Fifth server **36** comprises, in an exemplary embodiment, a DEC-Alpha server having 512 Mb RAM and 12-Gb disk capacity, with 3.2c UNIX and 7.2.2.3 Oracle resident therein.

The desired batches are prefetched (step **951**) from the long-term storage unit **34** and temporarily stored (step **952**) in a cache **38**, as directed by the OSAR system **322** in the fourth server **32** under the control of the fifth server **36**. These prefetching and temporary storage steps **951,952** confer a speed advantage over having readers access the long-term storage unit **34** directly, which is comparatively slow, whereas the cache **38** response time is rapid. An exemplary cache **38** for use in the system comprises a FileNet

residing on the OSAR server and contains 12 GB of magnetic storage for this transient database.

The fifth server **36** contains a first database **362** associating each answer batch with a qualification required of a reader (e.g., sixth-grade math, New York State test). A second database **364** resident therein contains a list of qualifications possessed by each reader. A third database **366** resident therein contains the form data for each answer, including the number of questions and pages in the test, how each answer is to be scored, and in what form the answer image is to be presented to a reader. For example, information on the page in FIG. 7A would include the location of the answer blank **73** to Question #2 and the answer scale to be used in scoring that question (e.g., a score of 1-5).

After the answer batch is lodged in the cache **38**, the question qualification **362** and forms **366** databases are referenced (steps **953** and **954**), and a work queue is established, which is selected by a supervisor managing a group of readers (step **955**).

When a reader logs onto a workstation **50**, his or her qualifications will have been checked by the supervisor. The reader receives an answer from the chosen batch for scoring (step **957**). The answer image is formatted for display (step **958**) and delivered to the reader's workstation **50** (step **959**).

The formatting step **958** comprises accessing the forms database **366** to determine how the answer image and scoring protocol are to be displayed to the reader. For example, an area of interest **73** (FIG. 7A) or **83** (FIG. 8A), which comprises the space left for writing in an answer, is delineated on each page image, and it is this area that initially appears on the reader's workstation screen **51** (FIGS. 7B and 8B). An important feature

of the present invention is that the reader can also access the remainder of the image if desired, which can be necessary if the student has written outside the area provided for that particular question (see FIG. 6, steps **988,989**), and may even spill over onto another page. Such access is typically provided by a scroll bar **510** such as are known in the art in Windows®-type applications (FIGS. 7B and 8B). This feature provides an advantage over other systems known in the art in which the visual image is clipped to include only a predetermined area of interest, in which case this extra display information is lost.

Once the reader has finished with an answer, a score is entered into the workstation **50** (step **960**), which is delivered to and stored at the fifth server **36** (step **962**). Next the reader receives another answer to score from the same batch, if there are additional answers of the same test question remaining in the queue (step **962**). If that queue is empty, the supervisor selects another answer batch from the queue (step **955**). Once the batch is completely scored, the scores are assembled and transmitted by the fifth server **36** to the mainframe **40** (step **965**), where all the individual answer scores are correlated for each booklet and a total test score is calculated. This step typically occurs once per day.

The progress and speed of any particular reader or the status of a particular queue are monitored by accessing the fifth server **36**, which maintains statistics (step **963**) and a table of workflow queues (step **964**). Access to this information may be limited, for example, to supervisory or managerial personnel by means known in the art.

The Scoring and R ader Monitoring System and Method

One aspect of the scoring system and method of the present invention is illustrated in the flowchart of FIG. 6, which provides further details of the steps occurring between step **957**, the delivery of an answer to a reader for scoring, and step **960**, the entry of a score, in FIG. 5.

As indicated above, the answer, prior to delivery (step **957**), is formatted for electronically selecting an area of interest **73** or **83** for displaying to the reader, along with a scroll bar **75,85** for permitting the reader to access the remainder of the page **12,12'** (FIGS. 7A,8A). The answer is also formatted for scoring protocol, and, as illustrated in FIGS. 7B and 8B, a score button bar **76,86** is provided that corresponds to the scoring range for that question. In FIG. 7B, the scores are given on a scale of 1 to 5; in FIG. 8B, 1 to 4. Answers that cannot be give a numeric grade are considered invalid and are scored in a separate category (e.g., blank, foreign language, off-topic).

Scoring facilities such as are known in the art generally comprise groups of readers having similar qualifications who are assigned to types of questions to score. Such groups may be further subdivided into smaller groups, and a commensurate management tree structure created. Preferably this tree structure is mirrored in the hardware architecture (FIG. 3), wherein, for example, a supervisor has access to all reader workstations **50** in that group.

To proceed with scoring, formatted answer and score button bar **76,86** are displayed to the reader (step **980**). If the reader has a question regarding the scoring protocol (step **981**), a query is sent electronically upline to the reader's next-level supervisor (step **982**).

If that supervisor can answer the question (step **983**), a response is transmitted electronically to the reader (step **984**); if that supervisor cannot answer the question (step **983**), a query is transmitted upline to the next-level supervisor (step **982**), looping through as many levels of supervisors as are present until the query can be addressed. When the query is answered, the answer is relayed to the reader through all intermediate query relayers (step **984**) so that all levels of personnel can view the answer to the query. While the query is being routed, the reader can continue scoring another answer.

Once the query is answered, or if there was no query, the reader can continue scoring that answer. If the test is in geometry or some other discipline wherein an answer can comprise the drawing of a diagram, a software tool is made available to the reader to assist in scoring (step **985**). If needed, the geometric tool is fetched (step **986**) and utilized to score the answer. In the example shown in FIG. 8B, a right triangle was drawn, and thus a floating protractor **87** can be used to measure the right angle **840**. Also available are screen-manipulable tools for measuring areas, lines, and circles. This software in the preferred embodiment comprises a custom-designed package.

The reader then determines if the image display is sufficient for scoring the answer (step **987**). If so, the reader can score the answer (step **960**); if not, the reader can use the scroll bar **510** to access another area of the page, or an area on another page, to view additional parts of the visual image (step **988**).

Another aspect of the present invention includes a system and method for monitoring the scoring effectiveness of a reader, the steps for which are included in the flowchart of FIG. 9. A group supervisor, for example, sends a calibration answer having

a predetermined target answer to a reader (step **990**). This answer is interspersed with "real" student answers and are substantially identical in form thereto, which permits the calibration to be performed transparently.

A score entered by the reader (step **991**) is collected (step **992**) and electronically compared with the target score (step **993**) for providing an indication of effectiveness (step **994**). At the same time, the scoring time can be collected (step **992**) and compared with a target scoring time (step **993**) for a calculation of scoring efficiency (step **994**).

Another check is performed by comparing a score given holistically and analytically by an inconsistency application (**970,** FIG. 2). If these scores differ too widely, they are rechecked to ensure that an error was not made.

As mentioned, scoring is typically performed by electronically linked groups of readers having similar qualifications. Thus the method illustrated in FIG. 9 can also be expanded to monitor the effectiveness and efficiency of the entire group of readers (steps **991-991"**) substantially simultaneously if desired.

Statistics can also be amassed at the system level on scoring progress for each workflow queue, broken down into scoring groups or by individual readers. As these statistics are being collected continuously, the system provides enormous flexibility in terms of optimization of effort.

System Architecture and Software System Flow

An exemplary architecture for a preferred embodiment of the present system **10** is schematically illustrated in FIG. 3, and comprises a fiber-optic database distributed interface **61** (FDDI) having a throughput of 100 Mbits. In this embodiment a 100-Mbit fiber is employed to link the subsystems.

Connected to the FDDI **61** are the Novell server **28** and the UNIX servers **30** and **36**. The cache **38** and the jukebox **34** are connected through the server **30**. A first hub **62** is connected to the FDDI **61** and, via 10-Mbit lines, to the scanners **20**, which output to magnetic tape **41**, as shown in FIG. 1, and thence to mainframe **40**. A second hub **63** is connected to the FDDI **61** and, via 10-Mbit lines, to the reader workstations **50**. Second hub **63** acts as a concentrator and has 100 Mbits from FDDI **61**. Each workstation **50** has 10 Mbits out on ethernet.

It is believed that this architecture confers advantages over systems previously known in the art, which employ token rings having limited throughput and one server per group. The present system comprises central servers supporting all readers, which permits improved flexibility both in hardware and in software implementation. This architecture further permits the adaptation to remote scoring sites.

The software system flow is illustrated in FIG. 2, wherein each "scoring work unit," (SCO WRK UN), here shown as **74** in FIG. 7A, comprises an answer image. The applications bear like numbers to the steps they perform in the flowcharts. In addition, various caches are maintained between applications, including: transaction data **971** from the scanning operation **907**; rescanned **972** and new booklet **973** information from HPII

document committal; image quality work units **974** acted upon by the image quality application **912**, the distributor application **957**, the question application **981**, and the scoring application **960**; regular holistic and analytical scores **975** from the scoring **960**, route **965**, and question **981** applications; domain item questions **976**, wherein pending questions are held until they are resolved; pending scores **977** for holding incomplete scores; calibration work units **978**; and inconsistency work units **979**.

New Form Definition

The system of the present invention further comprises a table-driven system for entering new project configurations, including teams, forms, domains, and orders. This allows the scoring to be customized for each project without any recoding.

It may be appreciated by one skilled in the art that additional embodiments may be contemplated, including analogous systems and methods for processing questionnaires.

In the foregoing description, certain terms have been used for brevity, clarity, and understanding, but no unnecessary limitations are to be implied therefrom beyond the requirements of the prior art, because such words are used for description purposes herein and are intended to be broadly construed. Moreover, the embodiments of the apparatus illustrated and described herein are by way of example, and the scope of the invention is not limited to the exact details of construction.

Having now described the invention, the construction, the operation and use of preferred embodiment thereof, and the advantageous new and useful results obtained

thereby, the new and useful constructions, and reasonable mechanical equivalents thereof obvious to those skilled in the art, are set forth in the appended claims.